Nature and timing of lower crust of the Robertson Bay terrane (northern Victoria Land, Antarctica)

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Summary This study is aimed to increase the knowledge on the nature and age of the crust underneath the turbidites in the Robertson Bay terrane through the study of crustal xenoliths brought to the surface by alkaline Cenozoic lavas. Petrographic and geochemical data allow to distinguish three different types of xenoliths: (A) K–feldspar-rich with an alkaline geochemical affinity, thought to represent cumulates linked to the Cenozoic igneous activity; (M) mafic granulites, with geochemical affinity variable from island-arc tholeiite to calc-alkaline; (F) felsic granulites found as both (F1) K-rich, with euhedral microcline, and (F2) low-K types, with geochemical composition varying from granite- to metasedimentary-like. Types M and F are thought to be representative of the lower crust. Furthermore, U–Pb dating of zircons by laser-ablation ICP-MS from the F2 sub-type (concordant ages clustering at ~490 and 360Ma) suggests the formation of juvenile crust during the Ross convergence process. Overall, these results reveal the composite nature of the lower crust of the Robertson Bay terrane.

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Introduction

The interpretation of the geodynamic setting of the Early Paleozoic Ross Orogen in northern Victoria Land is based since two decades on the scenario of three fault-bounded lithotectonic units (Bradshaw and Laird, 1983; Gibson and Wright 1985) comprising from SW to NE: Wilson, Bowers and Robertson Bay terranes. In this frame, different hypotheses have been formulated on the kinematics and dynamics of the juxtaposition/accretion of these different units (Stump, 1995), including variable number and direction of dip of subducting plates (Kleinschmidt and Tessensohn, 1987; Meffre et al., 2000; Weaver et al., 1984). A key role in all these reconstructions is played by the outermost Robertson Bay Terrane. There is not yet agreement on its origin, interpreted so far as either totally/partly exotic or linked to the continental margin. The nature of its crust buried under the thick turbidite sequences has been considered as oceanic based on aeromagnetic studies (Finn et al., 1999), although no direct evidence data have been still presented.

This study is designed to collect evidence about the nature and age of the inaccessible intermediate-lower crust underlying the Robertson Bay turbidites by studying the petrological, geochemical and geochronological features of deep-seated xenoliths brought to the surface in the Robertson Bay terrane by the Cenozoic volcanic activity.

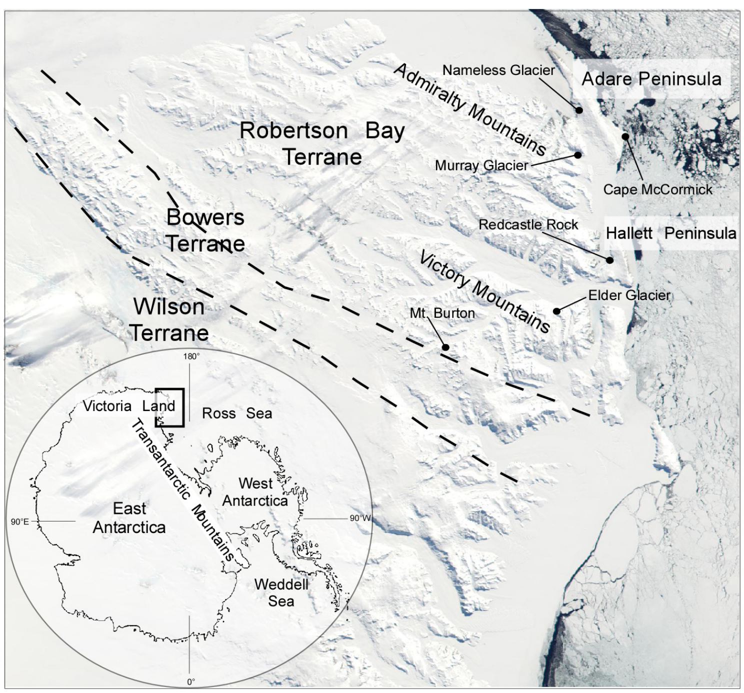

Figure 1. Location map of sampling localities.

Geological setting

The continent-wide Transantarctic Mountains represent the roots of the early Paleozoic Ross Orogen uplifted during the Cretaceous–Cenozoic activity of the West Antarctic rift system (Fitzgerald and Stump, 1997), that also led to the generation of the plutonic-volcanic alkaline province (LeMasurier and Thomson, 1990; Rocchi et al., 2002). The Ross Orogeny is commonly acknowledged as the result of the south-westward subduction of the paleo-Pacific plate under the margin of the East Antarctic craton (Kleinschmidt and Tessensohn, 1987; Goodge, 2002). The subduction stage was followed by collision resulting, in northern Victoria Land, in the accretion to the craton margin of a series of terranes, whose nature and origin is a matter of debate. These terranes are three main fault-bounded lithotectonic units, called Wilson, Bowers and Robertson Bay terranes (Fig. 1). The latter consists of a thick, folded series of turbiditic greywackes and mudstones of distal character metamorphosed under low- to very low-grade conditions, intruded during the Middle-Late Devonian by the granite association called Admiralty Intrusives. For the Robertson Bay turbidites a continental source has been suggested (Stump, 1995; Roland et al., 2004), whereas the nature of the underlying basement remains largely unknown.

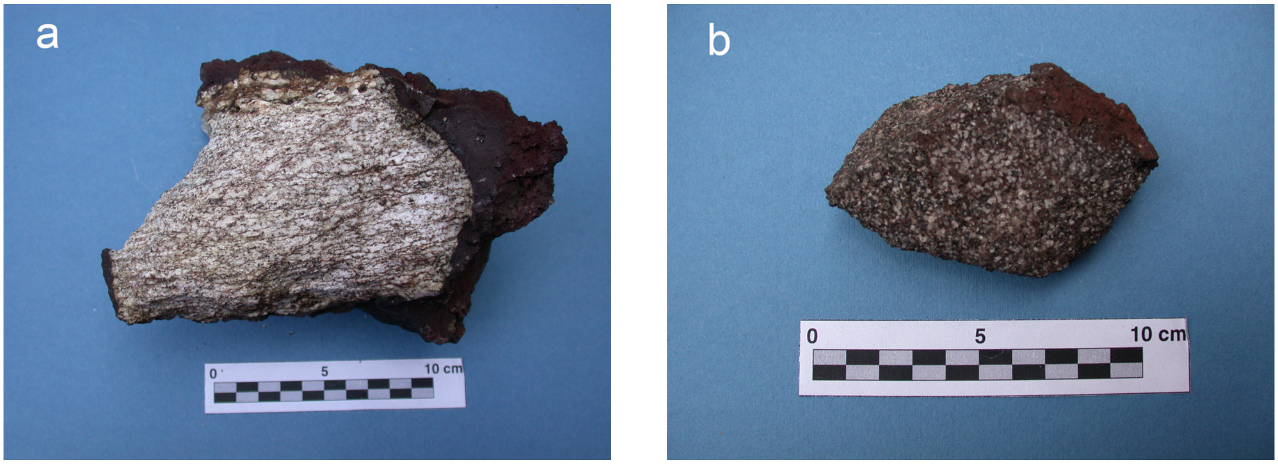

Figure 2. Macroscopic features of felsic (a) and mafic (b) xenoliths.

Petrographic, geochemical, and geochronological results

Crustal and mantle xenoliths of variable lithological nature have been sampled from several volcanic centres of the McMurdo Volcanic Group in the Robertson Bay terrane. The xenoliths were found mainly as cored dense bombs from scoria cones in the coastal Adare Peninsula (Berg and Wu, 1992), Hallett Peninsula, and in the inland Victory and Admiralty Mountains (Fig. 1). Both crustal and mantle xenoliths were sometimes collected from the same scoria cone. The size of crustal xenoliths varies from 2 to 20 cm in diameter, and they can be grouped, depending on their mineral assemblage, into K-feldspar-bearing felsic (A), felsic (F), and mafic (M) types (Fig. 2). K-feldspar-bearing felsic xenoliths (A-type) are medium- to fine-grained and are characterized by sutured texture with interlobate-amoeboid grain contacts and are mainly composed of K-feldspar, along with minor clinopyroxene and epidote. Xenoliths of the felsic type (F) are the most common, with medium to coarse-grained granoblastic textures and occasional mortar texture ribbons, indicating local ductile deformation (Figs. 3a and 4a). They consist mainly of plagioclase, quartz, orthopyroxene and K-feldspar with relative abundances pointing to enderbite to charnockite granulite types. Some xenoliths contain anhedral or large subhedral (up to 1 cm) microcline crystals (F1), in a typical hypidiomorphic granitic texture. Mafic xenoliths (M-type) show medium- to coarse-grained, granoblastic texture with polygonal grain contacts (Figs. 3b and 4b). They consist mainly of orthopyroxene, clinopyroxene, plagioclase, and, rarely, quartz and olivine.

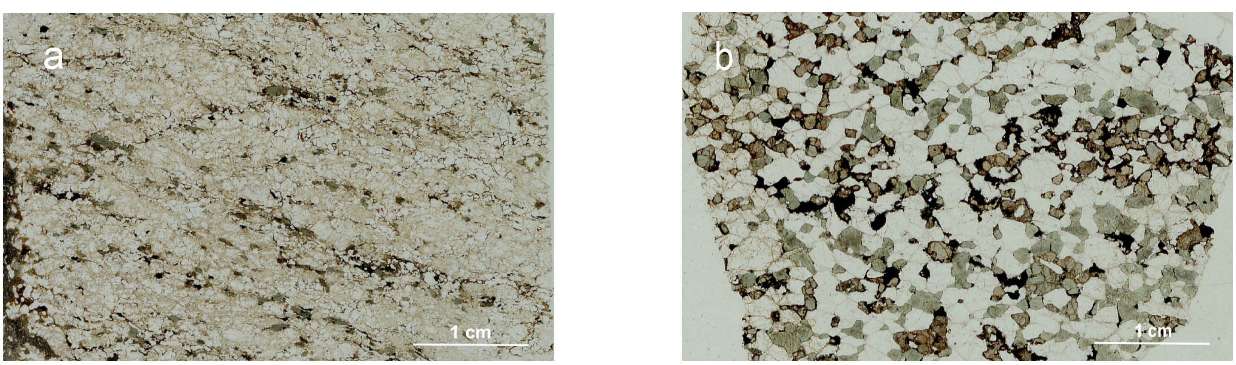

Figure 3. Whole thin section scanned images of felsic (a) and mafic (b) granulite.

Major element compositions define three groups corresponding to the three petrographic A, M and F types described. Rare earth element (REE) distribution from different groups are variable and distinctive. Mafic group (M) display two different chondrite-normalized pattern types for different sampling localities: Cape McCormick xenoliths have a flat trend with a slight positive Eu anomaly, whereas the xenoliths sampled at Nameless Glacier show fractionated patterns. REE patterns of felsic xenoliths (F-type) are variable, showing more of less fractionated profiles.

The K-feldspar-bearing felsic group (A-type) displays patterns extremely enriched in LREE, comparable to that of the host lava: this close compositional similarity with the products of the Cenozoic magmatism suggest and origin linked to cumulus processes during the evolution of the McMurdo Volcanic Group.

Preliminary U–Pb geochronological data have been collected on zircons by laser ablation ICP-MS separated from two low-K felsic xenoliths. Concordant U–Pb data on rims and cores yield $^{206}Pb/^{238}U$ ages defining two main peaks on cumulative probability distribution plot, at ~490 Ma and ~360 Ma. The former is defined by analyses on areas with better-preserved igneous zoning patterns, whereas the latter by data from areas characterized by secondary structures.

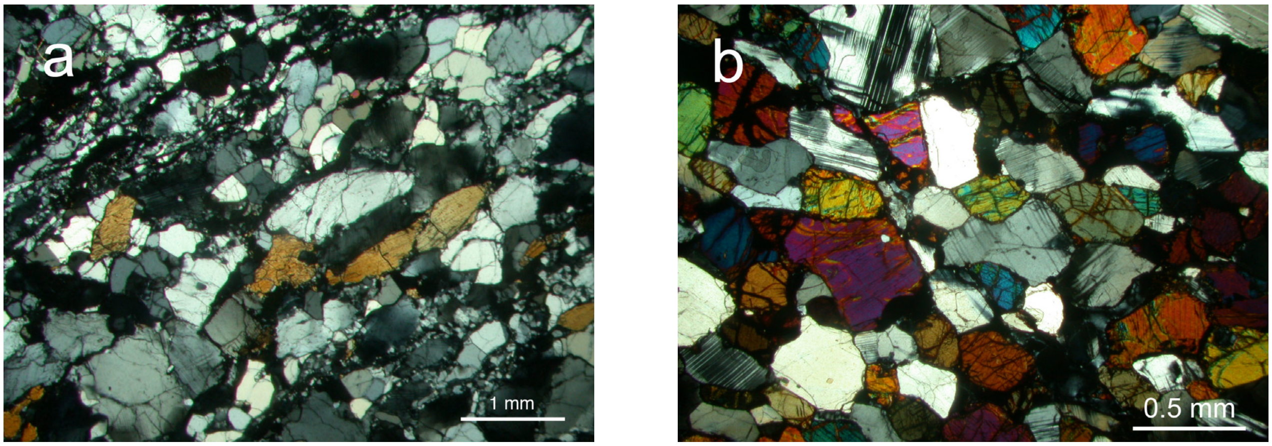

Figure 4. Crossed polar photomicrographs of felsic (a) and mafic (b) xenoliths.

Discussion and conclusions

Petrographic and geochemical features of different types of crustal xenoliths lend support to the occurrence of a wide compositional heterogeneity of the intermediate-lower crust of the Robertson Bay terrane. Felsic xenoliths represent the most abundant group, showing variable trace element distribution, ranging from granite- to metasedimentary-like. This group also includes high-K granitic xenoliths, with large K-feldspar crystals tipical of an igneous texture. U–Pb geochronological data on zircons of low-K felsic xenoliths yield age clustering at ~490 and 360 Ma, suggesting formation of juvenile crust during the Ross convergence process, then reworked synchronously with the emplacement of the Admiralty granites. Some mafic xenoliths display affinity with island arc tholeiite magmas, while others have affinity with calc-alkaline basalts. Results point out the complex nature of the crust of the Robertson Bay terrane, probably a composite of a Ross-age juvenile component and a granitic-like crust.

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